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SENSOR DEVICE FOR A VEHICLE CONTROL SYSTEM

This invention relates to a sensor device for a vehicle control system. A sensor is an electronic component which converts quantifiable values into electric signals, reporting them for additional computer-assisted processing.

Modern vehicles have a variety of sensors, which in some cases are incorporated in the vehicle and support the driver in critical situations, increase driving comfort, or reduce fuel consumption and also environmental pollution as a result. A system to increase driving comfort may be a radar-supported, automatic headway control. A method to reduce fuel consumption is a gear change-adapted system, i.e., optimal automatic gear changing for minimal fuel consumption.

While such systems function reliably in normal situations, difficulties may appear under certain circumstances. Thus, with radar-supported, automatic headway controls problems may arise in curves or with objects, like bridge piers if the radar signal is only available to interpret one object configuration. With the gear change-adapted method only actual values are available, like an instantaneous turning moment to derive a moment value for the gradient or also an instantaneous steering angle deflection to derive a moment value of the curve. Therefore, a "projection" of future values and thus an estimate of a future evolution are not possible.

The availability of geographical information stored in digital road maps represents an opportunity of providing vehicle control systems with additional, more versatile, information. Such a system is described in DE 37 00 552 A1. Hereby a vehicle-based navigation system with a digital road map includes additional vital information. This information is used upon reaching the assigned geographical position and/or is to control systems in the vehicle. By outputting the information and/or controlling the system in the vehicle, automatically collected driving and environmental information, like speed, can be considered.

EP 1 111 336 A1 describes a procedure for the universal application of a digital roadmap, whereby routes are stored in the digital roadmap in the form of edges and nodes to control the vehicle. Beginning at the current location of the vehicle various possible routes are calculated. In the process an "electronic horizon" is created whose extension is dependent on the type of each route ahead. The geographic information assigned to each route within the electronic horizon is stored in a buffer. The geographic information stored in the digital road map may vary in accuracy in order to be used in different vehicle control systems. This is effected by correspondingly identifying the information. The information stored in a buffer is supplied to the vehicle control system by a broadcast mechanism (transmission via a vehicle-based network). Each system is configured in such a way that it only receives the information required by the vehicle.

The use of geographic information stored in a digital roadmap, however, entails several disadvantages. On the one hand, digital roadmaps are designed and correspondingly optimized especially for vehicle navigation. In the present case, navigation is not the main reason for using the digital roadmap, but rather the "storage function" of geographic information to operate the vehicle control systems. At the same time, the digital road map includes much information not needed in this field of application. Reference is made here to Figure 1. If only geographic information to operate the vehicle control systems is kept, unnecessarily expensive storage space is used, which in turn requires the installation of expensive devices in the vehicle for such an amount of data, e.g., a CD ROM or DVD player. The actually required information could be stored in an economical memory chip instead. In addition, an expensive, vehicle-based navigation system must be incorporated to operate the digital roadmap, even in cases where such navigation system is actually not needed, e.g., if the vehicle uses a centrally-based navigation system.

In addition, as shown in EP 1 111 336 A1, for instance, an extensive and complicated configuration, and transmission and reception operations are necessary to make the geographic information available to the vehicle control systems. The reason is the "universal" use of only one digital roadmap for different vehicle control systems. On the one hand, this increases the data traffic in the vehicle's internal network, e.g. the CAN ("Controlled Area Network"), as well as the complexity of the corresponding system structure. On the other hand, it is fault-prone, not allowing for a separation between comfort functions and safety critical functions, whereby the geographic information provided turns out to be unreliable for use in vehicle control systems.

The task underlying this invention is to provide a vehicle control system required geographic information in an easy, economic and stable manner.

According to this invention, the task is solved by the sensor device characterized in Claim 1. The subsequent claims involve advantageous developments and improvements of this invention.

The essence of this invention consists of a geographic information storage buffer, whereby the geographic information is suitable for one or more vehicle routes using an input interface to select a subset of the geographic information stored in the buffer, whereby the selection is activated by providing at least one parameter value at an input interface, as well as an interface to output the subsets of geographic information corresponding to the provided parameter values , whereby the output data is sent for further processing in the vehicle. In other words, neither a digital roadmap nor a "navigable" (suitable for vehicle navigation) data set is required. Not even a navigation system to control the digital roadmap is required.

According to this invention only a geographic information buffer cache is provided. This buffer records geographic information suitable to describe at least one possible rout,

which wholly or partially corresponds to a route from a starting to an arrival point. This procedure at the same time offers several

advantages. It is the first time a complete separation between geographic information provided for use in vehicle control systems and geographic information used for navigation has been implemented. This is a striking advantage in safety critical vehicles, for instance.

This aspect in particular is further developed advantageously, if the geographic information used by safety critical vehicle control systems is certified, i.e., it is specially checked by state agencies or other trustworthy institutions. A commercially available digital roadmap is not certified, nor could it possibly be certified due to the huge amount of data it contains. A mixture of certified and uncertified information, which would be questionable from the safety point of view, is effectively prevented by the invention-related isolated buffer cache for certified geographic information used by safety critical vehicle control systems.

A further advantage of the separation between the geographic information foreseen for use in vehicle control systems and the geographic information used for navigation is the independence thereby obtained by the vehicle manufacturer from navigation systems producers. Navigations systems, as electronic consumer goods, are subject to a quick production sequence and constant advancements. Thus, with every new generation of navigation systems used in vehicles new adaptations are required, e.g., of the interfaces and of checks and functional tests, especially with safety critical vehicle control systems. Such advancements in navigation systems, however, only involve the navigation function, as the provision of geographic information for vehicle control systems is all but a "secondary task" of a navigation system. The input and output interfaces of the invention-related sensor device, which constantly remain the same, represent significant cost and labor savings.

Another advantage of the invention in particular consists of its use in commercial vehicles. Commercial vehicles usually drive along only one or a few routes. Therefore, a

comprehensive digital roadmap is unnecessary in a commercial vehicle. In addition, commercial vehicles usually do not use a vehicle-based navigation system, since the drivers generally know the few routes to be driven along very well, and centrally based navigation and management systems are frequently used, e.g., "Fleetboard" by the Daimler Chrysler Company. Due to the cost pressure in the transport business, vehicle-based navigation systems have had to be dispensed with, and no geographic information could be used in the vehicle control system. This invention remedies that problem.

Commercial vehicles in particular usually have additional control devices. In addition to the centrally based navigation and management system already in use, in the near future it will be compulsory to outfit heavy commercial vehicles with a device to calculate the road impact fee. Such devices comprise the calculator and additional sensors incorporated in the invention-related buffer. These additional sensors are especially for positioning, e.g., with GPS ("Global Positioning System"). Further additional sensors are used for monitoring and correcting of positioning errors, e.g., an odometer or an electronic gyroscope. Furthermore, appliances to communicate with external units are provided by means of GSM ("Global System for Mobile Communications") or DSRC ("Dedicated Short Range Communication" short range communications), for instance. Actually, positioning itself is carried out through these appliances.

In a further embodiment these appliances are advantageously assembled in a single packaged circuit. Thus, at least some of the additional sensors, the calculator and the invention-related sensor device form a compact, standardized and therefore low cost telematics platform. In addition to the invention-related sensor device it comprises the in-vehicle component of a centrally based navigation and management system and/or the road impact fee calculator.

According to this invention, one or several position-related parameter values provided at the input interface of the buffer to select a subset of the stored geographic information. Further advantageous advancements allow for other parameter combinations in addition to the current position of the vehicle. In particular these are partial sections of the current route or geographic area, which is provided by a centrally based navigation system. A geographic area is formed by a "funnel" opening around the current vehicle position, whose size depends on the vehicle speed and whose opening angle depends on the vehicle direction. Here a variety of possibilities exists depending, in particular, on the type of the vehicle control system. The connection of the input or output interface of the buffer to the vehicle-based data network, e.g., CAN ("Controlled Area Network") is thereby advantageous. This way, an especially easy transmission of the required additional sensor values and/or geographic information is possible.

Alternatively, an additional calculator in the vehicle to control the invention-related sensor device can be provided, so that the sensor device has its own calculator to determine the position-related parameter values, e.g., a vehicle computer or control device. The incorporated calculator can directly process additional sensor data and thus determine the position independently. In another embodiment the incorporated calculator selects the next partial section of a route determined by a centrally based navigation system. Here a variety of embodiments is possible. Naturally the calculator and the sensor device can thereby also be designed as one structural unit. In addition, a sensor device can be assigned to each vehicle control system. Alternatively one sensor device can be used by several vehicle control systems. In the process one or several incorporated calculators can again be provided. Any such combinations are thereby possible.

It is advantageously proposed, that the invention-related sensor device be designed as an "intelligent" sensor. An intelligent sensor enables an especially easy use based on the "plug & play" (self- configuration without additional adaptation) principle

According to the invention, the geographic information stored in the buffer is not all-purpose information for navigation, for the vehicle control systems operations or for other purposes, but they are especially provided for the operation of one or several vehicle control systems, instead. Thereby a significant reduction of the extent of the required data results, as there is no need for the data to be suitable for navigation.

In an especially advantageous advancement a storage format of such a type is chosen for the geographic information stored in the buffer, which requires very little storage space and, in particular, is highly accurate. Since it is not suited for navigation, such a data format has so far not been used for the storage of geographic information in a vehicle. This innovative data format basically turns away from the usual reproduction of sections of a digital roadmap using edges and nodes. Especially for non-straight route sections, like curves, that type of reproduction is inaccurate and requires a great deal of storage space. The reason for it is that bends usually have the form of circular arcs or the form of a clothoid (Cornu spiral). Clothoids, or even curves whose curvature increases proportionally with the arc length, are used as a transition between circular arcs and straight sections or between two circular arcs. By means of a parameter-based description of non-straight route sections as a circular arc or a clothoid or a spline, enormous storage space is saved, since only the corresponding parameters must be stored. At the same time, the accuracy of the geographic information is significantly increased, since no fault-prone "approximate solution" in the form of an approximation with edges and nodes is stored. Instead the exact reproduction is stored in the buffer. In addition, the access to the geographic information is accelerated and the assigned processing unit is relieved of calculating tasks.

According to this invention, only one or a few routes for the vehicle will be stored in the buffer. As already shown, this invention is especially advantageous in commercial vehicles. But from time to time it is necessary to provide new geographic information, not stored in the buffer so far. Naturally this becomes necessary, if completely new sections or routes are to be provided to the vehicle control systems, but also for cases when changes have been made to the already stored routes and due to road works or construction the geographic information in the buffer must be changed. These changes are made in an especially easy way, if the buffer can be overwritten. It is advantageous, if the geographic information is partially or incrementally or completely changeable and the various changes can be easily made. Naturally, these possibilities are based on the calculation code stored in the incorporated calculator potentially associated with the sensor device.

In another especially advantageous embodiment the buffer is designed as a flash ROM. Changes can thus be made comfortably without the risk of erroneously deleting the geographic information. The change is made by means of a data line connected to the buffer, which is accessible via an appropriate interface. In a further embodiment the buffer is designed as a mobile ram which is easily inserted by the vehicle driver into a bracket and so made accessible to EDP.

Because of the high certification expenses such certified geographic information is relatively expensive to produce and to acquire. Thus the use of large amounts of data, e.g., a digital roadmap, is hardly promising. On the other hand, such a mechanism is ideally supported by an overwritable buffer, as only one or a few routes are stored. It thus involves only moderate costs to keep up with the state of the art. This way, a reliable vehicle control system furnished with geographic information is always guaranteed.

The vehicles furnished with geographic information by the invention-related sensor are basically best operated on highways. In built-up areas the traffic flow is basically

influenced by the vehicles dynamics due to traffic lights and intersections and thus a reasonable use of the of the system in the vehicle is impeded. Therefore only countryside-related geographic information is advantageously stored in the buffer.

Numerous vehicle control systems benefit from being furnished with geographic information systems. On the one hand, the functions of already existing systems are further improved and can still be more versatile. An example for it is radar-supported, automatic headway control. In the process of evaluating an object configuration, further information, in addition to the radar signal, is provided by the detection of an object ahead using the geographic information. This considerably increases the certainty of detection in difficult situations like, for example, in curves or with bridge piers. With gear change-adaptation, the geographic information is now available in addition to the current values as an anticipation of future values , like for example, an instantaneous turning moment to derive a moment value for the gradient or also an instantaneous steering angle deflection to derive a moment value of the curve. Thus vehicle situations can be better estimated. For example, it is now possible to check, whether a gradient limit value was exceeded for a short time or whether a longer gradient section actually lies ahead.

On the other hand, supplying the invention-related sensor device with geographic information facilitates the design of totally innovative systems. A particular highlight here is an anticipated curve warning. Especially with commercial vehicles tip-over accidents with severe consequences repeatedly occur even with experienced drivers on frequently traveled routes. The invention-related sensor device is ideally suited to significantly reduce the number of such accidents. Further examples of innovative vehicle control systems are a curve light, i.e. a forward looking deflection of the headlights depending on the road curve , a warning of upcoming locations where the vehicle cannot pass, like bridges or narrow spots, a

situation-adapted warning and information management, so as not to overload the driver with stimuli, and a predicative diagnosis with actual, local load complexes acting on a component.

The state of the art with regard to the storage of geographic information as well as preferred embodiments of the invention is explained more closely by means of drawings.

Shown thereby are:

Figure 1: Storage requirement for individual types of information with a commercial digital roadmap.

Figure 2 a) and b): Storage requirement for individual types of areas with a commercial digital roadmap.

Figure 3 a) to c): Schemes of each preferred embodiment of the invention.

In Figure 1 the storage requirements for individual types of data with a commercial digital roadmap are visualized as a pie chart. Especially depicted here is the storage requirement of a digital roadmap in the form of a CD-ROM for Germany by the NavTech Company. In the following section various types of data stored according to the state of the art will be explained briefly.

Addresses, e.g., street names and house numbers, are the geographic information used as the starting and arrival points in navigation. Restrictions relate to unauthorized crossing at crossovers, e.g., turning prohibitions. Attributes are associated data providing additional information, for example, number of lanes on a road. Geometry relates to the geographic representation of the distance with edges and nodes. Topology is the logical interconnection of distances and nodes. Polygons relate to information to be visualized during navigation, e.g. the boundaries of woodland or cities. POI relates to points of interest which can be used as starting, arrival or intermediate points during navigation, landmarks, for instance. It can be clearly seen in Figure 1, that solely by omitting information like "addresses" and "polygons",

that is only needed for navigation, but not for the operation of vehicle control systems, forty-two percent less storage space is required.

In Figure 2 a) and b) the storage requirement is shown for individual areas for the same commercial digital roadmap as depicted in the pie chart of Figure 1. In the process "open spaces", i.e., outside urban and village areas, are differentiated from "built-up areas", i.e., in such areas. Figure 2 a) thereby shows the number of edges allotted to each area; Figure 2 b) shows the number of nodes allotted to each area. From Figures 2 a) and b) it can be clearly seen, that just by omitting geographic information about "built-up areas", i.e. areas not suitable for a useful operation of most vehicle control systems, between sixty-seven and seventy-four percent less storage space is required.

Figures 3 a) to c) in each case schematically depict preferred embodiments of the invention. Figure 3 a) shows a telematics platform. The telematics platform comprises various devices and calculators in a single packaged circuit. An additional positioning sensor , GPS, the invention-related sensor device including a 64 MB buffer, an additional 8 MB buffer for intermediate storage of calculations, an appliance for the communication between the vehicle and external units, GSM, and also for short range communications, DSRC. This telematics platform is very versatile. Actually, positioning of the vehicle is carried out by this device. With it the vehicle includes the telematics platform of a centrally based navigation and management system at the same time a road impact fee calculator. According to this invention it additionally, provides geographic information to the vehicle.

In Figure 3 b) the invention-related sensor device comprising a 64 MB buffer and the in-vehicle component of the centrally based navigation and management system are combined into one unit, "Fleetboard Reduced". This unit includes the in-vehicle component of the centrally based navigation and management system and is able to perform its own calculations. However, it does not include any additional sensors, e.g. positioning sensors.

These additional sensors are included in a separate unit to calculate road impact fees. The ETC unit comprises, in addition to its own calculator, an additional positioning sensor, GPS, an additional 8 MB buffer for the interim calculation storage, the communication appliance between the vehicle and external units, GSM, and also the appliance for short range communications DSRC. Apart from its main function, the independent calculation of road impact fees, the ETC unit by means of an information exchange provides information from the additional sensors to the "Fleetboard Reduced" unit as a "by-product". According to the invention, The "Fleetboard Reduced" unit provides vehicle control systems with geographic information.

In Figure 3 c) the invention-related sensor device comprising a 64 MB buffer and a road impact fees calculator are combined into a single ETC unit, . So, apart from the invention-related sensor device and the built-in road impact fees calculator, the ETC unit includes an additional positioning sensor, GPS, an additional 8 MB buffer for the interim calculations storage of , the communication appliance between the vehicle and external units, GSM, and also the appliance for short range communications, DSRC. The main function of the ETC unit is the calculations of road impact fees. The ETC unit exchanges information with the "Fleetboard Reduced" unit. For example, the ETC unit receives a route provided by the centrally based navigation system via the "Fleetboard Reduced" unit. Here the ETC unit provides the system in the vehicle with the information-related geographic information.